Dynamic Underground Stripping

60 times more successful than conventional methods of groundwater cleanup

Underground spills of volatile hydrocarbons (fuels or solvents) are especially difficult to clean up when they are trapped both above and below the water table. The problem is compounded in clay soils that have low permeability. The classic method of pump-and-treat takes many years, uses huge amounts of water to remove little contaminant, and is of little use for separate-phase contaminants such as free-product gasoline that have low solubility in water. Vacuum extraction has been very effective at removing highly concentrated contaminants above the water table, but neither method is useful below the water table.

Dynamic Underground Stripping removes separate-phase contaminants below the water table by heating the subsurface above the boiling point of water, and then removing both contaminant and water by vacuum extraction. Field results show that the process is more than 60 times as effective as pump-and-treat to treat contamination below the water table, and is 15 times as effective as vacuum extraction in the vadose zone (above the water table).

ADVANTAGES

- *Avoids the long-term investment of conventional methods*
- *Treats contamination both above and below the water table*
- *Removes separate-phase (free-product) contaminants*
- *Is effective in low-permeability soil*
- *Remediates quickly; reduces risk to population*

Three integrated technologies

Dynamic Underground Stripping relies on three integrated technologies.

Steam Injection. Steam is pumped into injection wells, heating the contaminated earth to 100°C. Steam drives contaminated water toward the extraction wells where it is pumped to the surface. When the steam front encounters contamination, volatile organic compounds are distilled from the hot soil and are moved to the steam / groundwater interface, where they condense and are pumped to the surface. Vacuum extraction after full steaming of the contaminated zone continues to remove residual contaminants.

This technology, developed at the University of California at Berkeley, is well suited to large permeable aquifers that contain separate-phase contaminants.

Electrical Heating. This LLNL-developed technique heats clay and fine-grained sediments and causes water and contaminants trapped within the soils to vaporize and be forced into the steam zones, where vacuum extraction removes them.

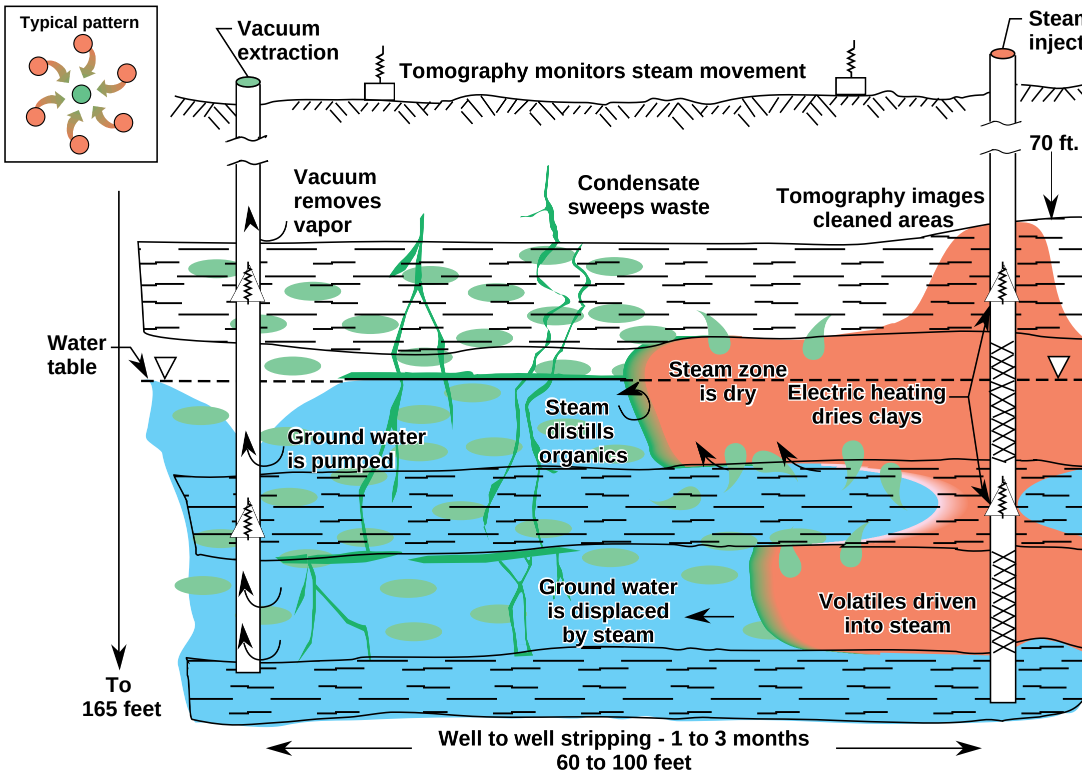
Electrical heating is ideally suited for tight, clay-rich soil and near-surface (less than 20 feet) cleanups.

Underground Imaging. To monitor the Dynamic Underground Stripping process, imaging methods are used to map the boundary between the contaminated zone and the cooler surrounding areas. Electrical resistance tomography has proven to be the best technique for obtaining near-real-time images of the heated zones.

This LLNL-developed technique is necessary for controlling the thermal process and for monitoring water movement. Tiltmeters provide additional information regarding the shape of the steamed zone.

Successful full-scale test

The first full-scale test of the method, at the site of a gasoline spill at LLNL, was extremely successful. The site had been treated with vacuum extraction since 1988; about 2000 gallons of gasoline had been removed from the vadose zone, but the rate had dropped to only two gallons a day by the end of 1991. During 21 weeks of operation in 1993, Dynamic Underground Stripping removed more than 7600 gallons of gasoline trapped in soil both above and below the water table.



In Dynamic Underground Stripping, steam drives contaminated water toward extraction wells and then heats the soil to distill organic compounds. Electrical heating dries and distills impermeable clays that the steam cannot readily penetrate. Geophysical techniques monitor the process. The method operates both above and below the water table and is particularly economically attractive for removing separate-phase contaminants.

The maximum removal rate was 250 gallons of gasoline a day. (Pump-and-treat would have removed only about a half gallon a day.) Approximately 100,000 cubic yards were cleaned at a cost of $60–$70 a cubic yard.

Recent work

Subsequent activities focused on final cleanup; about 1000 gallons more were removed before the end of 1993.

During the shutdown, gasoline concentrations in the water decreased, and vapor concentrations increased only slightly. Previous shutdowns with hot ground resulted in large increases in concentration when the treatment system was turned on again, presumably due to mobilization / vaporization of free-product gasoline. This and other factors such as the dramatic decrease in groundwater benzene concentrations—from several thousand parts per billion (ppb) before Dynamic Underground Stripping to less than 100 ppb in January 1994. There is no significant free-product gasoline remaining in the treatment zone.

This goal would have been unattainable by other methods in this time frame or cost range. The cost to remediate the LLNL site in six months was $6–8 million; the estimated cost using pump-and-treat was $20–60 million over 30–60 years.

Availability: We are pursuing commercialization of the technology. Negotiations are ongoing with companies interested in licensing and with remediation contractors and suppliers interested in partnering for further technology and market development.

Contact

Robin Newmark
Phone: (510) 423-3644
Fax: (510) 422-3925
E-mail: newmark1@llnl.gov
Mail code: L-208